U.S. Department of Transportation
Federal Highway Administration

Traffic Analysis Tools Primer

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Traffic Analysis Tools Primer

Entering the 21st century, the nation's transportation system has matured; it only expands its infrastructure by a fraction of a percentage each year. Yet, congestion continues to grow at an alarming rate, adversely impacting our quality of life, increasing the potential for accidents and undesired long delays. These are expected to only escalate, calling for the need for transportation professionals to increase the productivity of existing transportation systems through the use of operational improvements. In order to assess the potential effectiveness of a particular strategy, it must be analyzed using traffic analysis tools or methodologies.

There are several traffic analysis methodologies and tools available for use, however, there is little or no guidance on which tool should be used. These tools all vary in their scope, capabilities, methodology, input requirements and outputs. In addition, there is no one tool that can address all of the analysis needs of a particular agency.

The objective of the Traffic Analysis Tools Primer and its accompanying *"Decision Support Methodology for Selecting Traffic Analysis Tools"* is to assist traffic engineers and traffic operations professionals in the selection of the correct type of traffic analysis tool for operational improvements. These documents are intended to assist practitioners in selecting the c*ategory* of tool for use. Another objective of these documents is to assist in creating analytical consistency and uniformity across State Departments of Transportation (DOTs) and federal/regional/local transportation agencies.

The *"Decision Support Methodology for Selecting Traffic Analysis Tools"* document identifies the criteria that should be considered in the selection of an appropriate traffic analysis tool and helps identify the circumstances when a particular type of tool should be used. A methodology also is presented to guide the users in the selection of the appropriate tool category. This document includes worksheets that transportation professionals can utilize to select the appropriate tool category, and assistance to identify the most appropriate tool within the selected category. This methodology was developed for the Federal Highway Administration (FHWA) by Cambridge Systematics, Inc. in association with Dowling Associates and Dr. Alexander Skabardonis.

1.0 Overview of Traffic Analysis Tools

The Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21) and the Federal/State Clean Air legislation have reinforced the importance of traffic management and control of existing highway capacity. As transportation agencies deploy more sophisticated hardware and software system technologies, there is an increasing need to:

- Respond to recurring and non-recurring congestion in a proactive fashion;
- Predict and evaluate the outcome of various improvement plans without the inconvenience of a field experiment;
- Assist Transportation Management Center (TMC) operators in their decision-making by developing on-line and off-line strategies for assessing various freeway and surface street management and control strategies; and
- Evaluate and optimize traffic flow and traffic signal timing patterns to mitigate increasing or changing travel demands.

Out of these needs, traffic analysis tools emerge as one of the most efficient methods to evaluate transportation improvement projects. This document addresses quantifiable *traffic operations* analysis tools categories, but does not include real-time or predictive models. Traffic analysis tools may include software packages, methodologies, and procedures, and are defined as those typically utilized for the following tasks:

- Evaluating, simulating, or optimizing the operations of transportation facilities and systems;
- Modeling existing operations and predicting probable outcomes for proposed design alternatives; and
- Evaluating various analysis contexts, including planning, design and operations/construction projects.

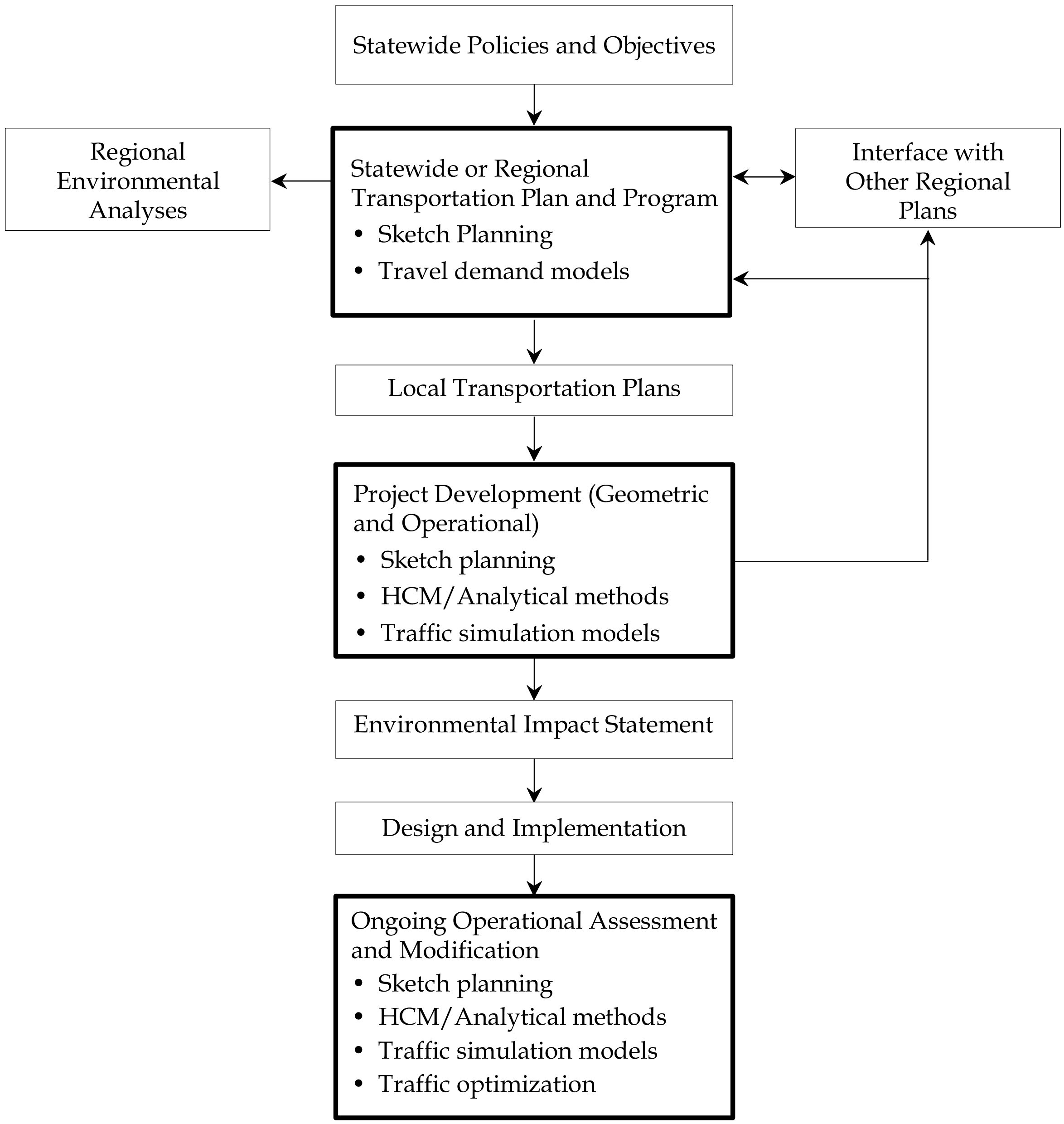
Figure 1 presents an overview of the transportation analysis process along with its various evaluation contexts and types of traffic analysis tools that are typically used in each context.

2.0 Role of Traffic Analysis Tools

Traffic analysis tools are designed to assist transportation professionals in evaluating strategies that best address the transportation needs for their jurisdiction. Specifically, traffic analysis tools can help practitioners to:

- **Improve the decision-making process –** Traffic analysis tools help develop better planning/engineering decisions for complex transportation problems. They are used to estimate the impacts resulting from deployment of traffic management and other strategies, and help set priorities among competing projects. In addition, they can provide a consistent approach for comparing potential improvements or alternatives.
- **Project potential future traffic –** Traffic analysis tools can be used to project and analyze future traffic conditions. This is especially useful for planning long-term improvements and evaluating future impacts.

Figure 1. Overview of the Transportation Analysis Process



Note: Boxes outlined by a bold line represent primary realm of application of traffic analysis tools.

- **Evaluate planning/operational alternatives and prioritize –** This typically involves comparing "no-build" conditions with alternatives, which include various types of potential improvements. The impacts are reported as performance measures and are defined as the difference between the "no-build" and alternative scenarios. The results can be used to select the best alternative or prioritize improvements increasing the chances of having successful deployments.

- **Improve design and evaluation time and costs –** Traffic analysis tools are relatively less costly when compared to pilot studies, field experiments, or full implementation costs. Furthermore, analysis tools can be used to assess multiple deployment combinations or other complex scenarios in a relatively short time.

- **Reduce disruptions to traffic –** Traffic management and control strategies come in many forms and options, and analysis tools provide a way to cheaply estimate the effects prior to full deployment of the management strategy. They may be used to initially test new transportation management systems concepts without the inconvenience of a field experiment.

- **Present/market strategies to the public/stakeholders –** Some traffic analysis tools have excellent graphical and animation displays, which could be used as a tool to show "what if" scenarios to the public and/or stakeholders.

- **Operate and manage existing roadway capacity –** Some tools provide optimization capabilities, recommending the best design or control schemes to maximize performance of a transportation facility.

- **Monitor performance –** Analysis tools can also be used to evaluate and monitor the performance of existing transportation facilities. In the future, there is hope that monitoring systems can be directly linked to analysis tools for a more direct and real-time analysis process.

3.0 Categories of Traffic Analysis Tools

To date, numerous traffic analysis methodologies and tools have been developed by public agencies, research organizations, and various consultants. The traffic analysis tool categories include the following:

- **Sketch-planning tools –** Sketch-planning methodologies and tools produce general order-of-magnitude estimates of travel demand and traffic operations in response to transportation improvements. They allow for evaluation of specific projects or alternatives without conducting an in-depth engineering analysis. Such techniques are primarily used to prepare preliminary budgets and proposals, and are not considered a substitute for the detailed engineering analysis often needed later in the implementation process. Sketch-planning approaches are typically the simplest and least costly of traffic analysis techniques. Sketch-planning tools perform some or all of the functions of other analysis tool types using simplified analyses techniques and highly aggregate data. However, sketch-planning techniques are usually limited in scope, analytical robustness, and presentation capabilities.

- **Travel demand models –** Predicting travel demand, traffic operations, and impacts in response to operational strategies requires specific analytical capabilities, such as the prediction of travel demand and the consideration of destination choice, mode choice, time-of-day travel choice, and route choice, as well as the representation of traffic flow in the highway network. These attributes are found in the structure and orientation of travel demand models, mathematical models that forecast future travel demand from current conditions, and future projections of household and employment characteristics. Travel demand models were originally developed to determine the benefits and impacts of major highway improvements in metropolitan areas. However, they were not designed to evaluate travel management strategies, such as ITS/operational strategies. Travel demand models have only limited capabilities to accurately estimate changes in operational characteristics (such as speed, delay, and queuing) resulting from implementation of ITS/operational strategies. These inadequacies generally occur because of the poor representation of the dynamic nature of traffic in travel demand models.

- **Analytical/deterministic tools (HCM based) –** Most analytical/deterministic tools implement the procedures of the Highway Capacity Manual (HCM). These tools quickly predict capacity, density, speed, delay, and queuing on a variety of transportation facilities and are validated with field data, laboratory test beds, or small-scale experiments. Analytical/deterministic tools are good for analyzing the performance of isolated or small-scale transportation facilities, but are limited in their ability to analyze network or system effects. HCM procedures and their strengths and limitations are discussed in more detail in Section 5.0.

- **Traffic optimization tools –** Traffic optimization tools are primarily designed to develop optimal signal phasings and timing plans for isolated signal intersections, arterial streets, or signal networks. This may include capacity calculations, cycle length, and splits optimization including left turns, as well as coordination/offset plans. Some optimization tools can also be used for optimizing the ramp metering rates for freeway ramp control.

- **Macroscopic simulation models –** Macroscopic simulation models are based on deterministic relationships of flow, speed, and density of the traffic stream. The simulation in a macroscopic model takes place on a section-by-section basis rather than tracking individual vehicles. Macroscopic models have considerably less demanding computer requirements than microscopic models. They do not, however, have the ability to analyze transportation improvements in as much detail as microscopic models.

- **Mesoscopic simulation models –** Mesoscopic models combine properties of both microscopic (discussed below) and macroscopic simulation models. As in microscopic models, the mesoscopic models' unit of traffic flow is the individual vehicle. Their movement, however, follows the approach of macroscopic models and is governed by the average speed on the travel link. Mesoscopic model travel prediction takes place at an aggregate level, and does not consider dynamic speed/volume relationships. As such, mesoscopic models provide less fidelity than microsimulation tools, but are superior to typical planning analysis techniques.

- **Microscopic simulation models –** Microscopic models simulate the movement of individual vehicles, based on theories of car-following and lane-changing. Typically, vehicles enter a transportation network using a statistical distribution of arrivals (a stochastic process), and are tracked through the network on a second-by-second basis. Computer time and storage requirements for microscopic models are large, usually limiting the network size and the number of simulation runs that could be completed.

4.0 Analysis Tools Challenges and Limitations

Each tool and tool category are designed to perform different traffic analysis functions, and there is no one analysis tool that can do-all and solve-all. This section addresses some of the challenges and limitations of available traffic analysis tools.

- **Garbage in, garbage out.** If good data are not available, the user should consider a less data-intensive tool category, such as a sketch planning tool instead of microsimulation. However, the results of the simpler tool categories are usually more generalized, so the user should carefully balance the needs of a more detailed analysis with the amount of data required.

- **Limitations in empirical data.** Data collection is often the most costly component of a study. The best approach is to look at the ultimate goals and objectives of the task at hand and focus data collection on the data that are crucial to the study.

- **Limitations in funding** to conduct the study, purchase tools, run analysis scenarios, and train the users are often a consideration in a transportation study. Traffic analysis tools can require a significant capital investment. Software licensing and training fees can make up a large portion of the budget. Plus, the analysis of more scenarios costs money. When faced with funding limitations, focus on the project's goals and objectives, and try to identify the point of diminishing returns on your investments.

- **Training limitation.** Traffic simulation tools usually have steep learning curves, and some agencies suggest that transportation professionals do not receive adequate modeling and simulation training.

- **Limitations in resources** (staff, capabilities, and funding) to build the network and conduct the analysis. Most traffic analysis tools are resource-intensive to implement, especially the model construction and calibration (front-end) phases for simulation analyses. Careful scheduling and pre-agreed acceptance criteria are necessary to keep the project focused and on target.

- **Data entry**, and the **diversity and inconsistency of the data** needed to run each of the different tools are of issue. Each tool uses unique analysis methodologies, so the data requirements for analysis can vary greatly from tool to tool and by tool category. In many cases, data from previous projects contribute very little to a new analysis effort. Adequate resources must be budgeted for data collection.

- **Lack of understanding** of analysis tools limitations and assumptions. Often times, limitations and "bugs" are not discovered until the project is underway. It is important to glean experiences from past projects or communicate with fellow users of a particular tool or tool category, to assess the tool's capabilities and limitations. By researching other's experiences, the users can gain a better understanding of what they may be up against as the project progresses.

- **Not designed to evaluate all types of impacts that transportation strategies/applications produce**. The output measures produced by each tool vary, so the process of matching the project's desired performance measures with the tool's outputs is important. In addition, there are very few tools capable of analyzing ITS strategies and the impacts associated with them (reduction in incident duration, agency cost savings, etc.).

- **Lack of features.** Some analysis tools are not designed to evaluate specific strategies that the users would like to implement. This is especially more prevalent in modeling ITS strategies or other advanced traffic operations strategies. Often times "tricking" the tool into mimicking a certain strategy is a short-term solution, but there needs to be a degree of flexibility for the advanced users to customize the tools.

- **Desire to run real-time solutions**. Many tools require a significant amount of time to set-up, model and analyze. There is hope that future tools would be able to be linked to TMCs and detectors, so the analysis can be implemented directly and at real-time. In addition, this would allow transportation professionals to respond to recurring and nonrecurring congestion using real-time solutions.

- Often times, **simpler or more popular analysis tools are being used, although they might not be the best tools for the job**. Due to the high cost of some of the more sophisticated tools, lack of resources, past experience, and lack of familiarity with other available tools, many agencies prefer to use a tool currently in their possession, even if it is not the most appropriate tool for the project at hand.

- There are **biases against models and traffic analysis tools** in general, not only because of the challenges listed above, but because models are not always reliable and are often considered "black boxes." These users prefer "eyeballing" methods using back-of-envelope calculations, charts or nomographs to estimate the results. This may be adequate for simpler tasks, but today's complex projects require more advanced tools.

- **Long computer run times.** Depending on the computer hardware and scope of the study (i.e., area size, data requirements, duration, analysis time periods, etc.), an analysis run may range between a few seconds to several hours. The most effective approaches to addressing this issue involve utilizing the most robust computer equipment available and/or carefully limit the study scope to conform to the analysis needs.

5.0 HCM Strengths and Limitations

The HCM procedures are good for analyzing the performance of isolated facilities with relatively moderate congestion problems. These procedures are quick and reliable for predicting whether or not a facility will be operating above or below capacity, and are well tested with significant field-validation experience. The HCM procedures though, are generally limited in their ability to evaluate system effects.

Most of the HCM methods and models assume that the operation of one intersection or road segment is not adversely affected by conditions on the adjacent roadway. Long queues from one location interfering with another location would violate this assumption. The HCM procedures are of limited value in analyzing the following:

- Queues that spill back from one intersection to another;
- Queues that overflow turn pockets;
- Queues from city streets that back up onto freeway; and
- Queues from ramp meters that back up onto city streets.

There are also several gaps in the HCM procedures. The HCM is a constantly evolving and expanding set of analytical tools; and, consequently, there are still many real world situations for which the HCM does not yet have a recommended analytical procedure. The following list identifies some of these gaps:

- Multi-lane or two-lane rural roads where traffic signals or stop signs significantly impact capacity and/or operations;
- Truck climbing lanes;
- Short through lane adds or drops at a signal;
- Two-way left turn lanes;
- Roundabouts of more than a single lane; and
- Tight diamond interchanges.

6.0 Simulation Strengths and Limitations

Simulation tools are effective in evaluating the dynamic evolution of traffic congestion problems on transportation systems. By dividing the analysis period into time slices, a simulation model can evaluate the buildup, dissipation, and duration of traffic congestion. Simulation models, by evaluating systems of facilities, can evaluate the interference that occurs when congestion builds up at one location and impacts the capacity of another location.

Simulation tools, however, require a plethora of input data, considerable error checking of the data, and manipulation of a large amount of potential calibration parameters. Simulation models cannot be applied to a specific facility without calibration of those parameters to actual conditions in the field.

Simulation models, for all their complexity, also have limitations. Commercially available simulation models are not designed to model the following:

- Two-way left turn lanes;
- The impacts of driveway access;
- The impacts of raised medians;
- The impacts of on-street parking, commercial vehicle loading, and double parking; and
- The interference that can occur between bicycles, pedestrians, and vehicles sharing the same roadway.

Simulation models also assume "100 percent safe driving," so they will not be effective at predicting how changes in design might influence the probability of collisions. In addition, simulation models do not take into consideration how changes in the roadside environment (outside of the traveled way) affect driver behavior within the traveled way (for example, visibility obstructions or roadside distractions such as a stalled vehicle).

7.0 Differences Between HCM and Simulation

The HCM methodologies and tool procedures take a static approach to predicting traffic performance, while simulation models take a dynamic approach. The HCM estimates average density, speed, or delay over the peak 15 minutes of an hour, while simulation models will predict density, speed, and delay for each time slice within the analysis period (which can be longer than an hour).

Not only are there differences in approach, there are differences in the definition of the performance measures produced by simulation models and HCM tools.

- Simulation models report density for actual vehicles, while the HCM reports density in terms of equivalent passenger cars (trucks and other heavy vehicles are counted more than once in the computation of density);
- Simulation models report vehicle flows in terms of actual vehicles, while the HCM reports capacity for freeways and highways in terms of passenger car equivalents;

- Simulation models report delay only on the street segment where the vehicles are slowed down, while the HCM reports all delay caused by a given bottleneck (regardless of the actual physical location of the vehicles); and

- Simulation models report queues only on the street segment where the vehicles are actually queued, while the HCM reports all queued vehicles caused by a given bottleneck (regardless of the actual physical location of the vehicles).

8.0 Strategy for Overcoming Limits of HCM

Once a transportation professional has decided that the HCM procedures do not meet the needs of the analysis, the next step is to determine whether microscopic, mesoscopic, or macroscopic simulation is required. There are several simulation programs available for evaluating a variety of transportation improvements, facilities, modes, traveler responses, and performance measures. These analysis tools vary in data requirements, capabilities, methodology, and outputs. In addition, the performance measures between the simulation models and the HCM procedures may differ in definition and/or the methodology (e.g., number of stops may be estimated at speeds of less than 5 mph in one tool, but 0 mph for another).

If it is not necessary to microscopically trace individual vehicle movements, then the analyst can take advantage of the simpler data entry and control optimization features available in many macroscopic simulation models. However, macroscopic models often have to make certain assumptions of regularity in order to be able to apply macroscopic vehicle behavior relationships. If these assumptions are not valid for the situation being studied, then the analyst must resort to mesoscopic or microscopic simulation.

Simulation models require a considerable amount of detailed data for input, calibration, and validation. In general, microscopic simulation models have more demanding data requirements than mesoscopic and macroscopic models. Simulation models are also more complicated and require a considerable amount of effort to gain an understanding of the assumptions, parameters, and methodologies involved in the analysis. The lack of understanding of these tools often makes credibility and past performance (use/ popularity) a major factor in the section of a particular simulation tool. More information on this issue may be found in the *"Guidelines for Applying Traffic Micro-Simulation Modeling Software"* developed for the FHWA by Dowling Associates and Cambridge Systematics, Inc.

9.0 Criteria for Selecting the Appropriate Type of Traffic Analysis Tool

This section identifies criteria that can be considered in the selection of an appropriate traffic analysis tool type and helps identify under what circumstances a particular type of tool should be used. The *"Decision Support Methodology for Selecting Traffic Analysis Tools"* document provides a detailed assessment of criteria to be considered when selecting a type of traffic analysis tool.

The first step is the identification of the analysis context for the task at hand: planning, design, or operations/construction. Seven additional criteria are necessary to help identify the analysis tools that are most appropriate for a particular project. Depending on the analysis context and the project's goals and objectives, the relevance of each criterion may differ. The criteria include the following:

1. Ability to analyze the appropriate **geographic scope** or study area for the analysis, including isolated intersection, single roadway, corridor, or a network.

2. Capability of modeling various **facility types**, such as freeways, high-occupancy vehicle (HOV) lanes, ramps, arterials, toll plaza, etc.

3. Ability to analyze various **travel modes**, such as single-occupancy vehicles (SOV), HOV, bus, train, truck, bicycle and pedestrian traffic.

4. Ability to analyze various traffic **management strategies and applications,** such as ramp metering, signal coordination, incident management, etc.

5. Capability of estimating **traveler responses** to traffic management strategies including route diversion, departure time choice, mode shift, destination choice, and induced/ foregone demand.

6. Ability to directly produce and output **performance measures** such as safety measures (crashes, fatalities), efficiency (throughput, volumes, vehicle-miles of travel (VMT)), mobility (travel time, speed, vehicle-hours of travel (VHT)), productivity (cost savings) and environmental measures (emissions, fuel consumption, noise).

7. **Tool/cost effectiveness** for the task at hand, mainly from a management or operational perspective. Parameters influencing cost-effectiveness include tool capital cost, level of effort required, ease of use, hardware requirements, data requirements, animation, etc.

In the *"Decision Support Methodology for Selecting Traffic Analysis Tools"* document, each analysis tool category is evaluated against each criterion to identify whether or not a category of analysis tool is appropriate for use. Figure 2 summarizes the criteria that may be considered for the selection of a tool category.

- The users should begin by identifying the project's analysis context (discussed in Section 2.1).

- Next, the users would filter through Criteria 1 through 6 to limit the appropriate tool categories down to one or two options.

Figure 2 Criteria for Selecting a Traffic Analysis Tool Category

Analysis Context:
Planning, Design, or Operations/Construction

1 Geographic Scope	2 Facility Type	3 Travel Mode	4 Management Strategy	5 Traveler Response	6 Performance Measures	7 Tool/Cost-Effectiveness
What is your study area?	**Which facility types do you want to include?**	**Which travel modes do you want to include?**	**Which management strategies should be analyzed?**	**Which traveler responses should be analyzed?**	**What performance measures are needed?**	**What operational characteristics are necessary?**
• Isolated Location • Segment • Corridor/ Small Network • Region	• Isolated Intersection • Roundabout • Arterial • Highway • Freeway • HOV Lane • HOV Bypass Lane • Ramp • Auxiliary Lane • Reversible Lane • Truck Lane • Bus Lane • Toll Plaza • Light Rail Line	• SOV • HOV (2, 3, 3+) • Bus • Rail • Truck • Motorcycle • Bicycle • Pedestrian	• Freeway Mgmt • Arterial Intersections • Arterial Mgmt • Incident Mgmt • Emergency Mgmt • Work Zone • Spec Event • APTS • ATIS • Electronic Payment • RRX • CVO • AVCSS • Weather Mgmt • TDM	• Route Diversion - Pre-Trip - En-Route • Mode Shift • Departure Time Choice • Destination Change • Induced/ Foregone Demand	• LOS • Speed • Travel Time • Volume • Travel Distance • Ridership • AVO • v/c Ratio • Density • VMT/PMT • VHT/PHT • Delay • Queue Length • # Stops • Crashes/ Duration • TT Reliability • Emissions/ Fuel Consump • Noise • Mode Split • Benefit/Cost	• Tool Capital Cost • Effort (Cost/ Training) • Ease of Use • Popular/Well-Trusted • Hardware Requirements • Data Requirements • Computer Run Time • Post-Processing • Documentation • User Support • Key Parameters User Definable • Default Values • Integration • Animation/ Presentation

- Finally, Criterion 7 (cost/tool effectiveness) would be used to select the final tool category based on parameters outside the technical context of the analysis such as tool cost, training, hardware requirements, etc.

The *"Decision Support Methodology for Selecting Traffic Analysis Tools"* document presents a step-by-step guidance on tool selection process, along with a list of recommended further readings. A listing of available tools for each category and their web site links are provided in Appendix A.

The first step in selecting the appropriate type of traffic analysis tool is the identification of the analysis context of the project. Figure 1 illustrates a typical transportation analysis process, which contains several analysis phases, including:

- **Planning –** Includes short- or long-range studies or other state, regional, or local transportation plans (i.e., master plans, Congestion Management Plans, ITS strategic plans, etc.).

- **Design –** This analysis phase includes approved and funded projects that are going through alternatives analysis or preliminary design to determine the best option for implementation. This phase also includes the analysis of roadway features needed to operate at a desired level of service (LOS). Full design projects (i.e., horizontal/vertical alignments, pavement design, etc.) are not included under this category.

- **Operations/Construction –** These projects share many similar characteristics with design projects, but are performed to determine the best approach for optimizing or evaluating *existing* systems.

Table 1 presents the general relevance of each tool category for each analysis context, including planning, design, and operations/construction.

Table 1. Relevance of Traffic Analysis Tool Categories with respect to Analysis Context

	Analysis Tools/Methodologies						
Analysis Context	**Sketch Planning**	**Travel Demand Models**	**Analytical/ Deterministic Tools (HCM-based)**	**Traffic Optimi-zation**	**Macroscopic Simulation**	**Mesoscopic Simulation**	**Microscopic Simulation**
Planning	●	●	∅	○	∅	∅	○
Design	na	∅	●	●	●	●	●
Operations/ Construction	∅	○	●	●	●	●	●

Note: ● – The specific context is generally addressed by the corresponding analysis tool/methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context and some do not.
na – The particular methodology is not appropriate for use to address the specific context.

Before selecting a particular tool, users are strongly encouraged to assess the strengths and weaknesses of the specific analysis tools, as this document only presents a generalized view of each tool category. Appendix A provides a list of available traffic analysis tools by tool category, along with a web site link for further information, as of November 2002. An updated version of this list can be found at the FHWA Office of Operations web site at:

http://ops.fhwa.dot.gov/Travel/Traffic_Analysis_Tools/traffic_analysis_tools.htm

Appendix A

Traffic Analysis Tools by Category

Appendix A. Traffic Analysis Tools by Category

A.1 Sketch Planning Tools

Examples of sketch planning tools include:

- Better Decisions: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=165
- HDM (Highway Design and Management): http://hdm4.piarc.org/
- IDAS (ITS Deployment Analysis System): http://idas.camsys.com/
- IMPACTS: http://www.fhwa.dot.gov/steam/impacts.htm
- MicroBENCOST: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=166
- Quick HOV: http://www.dowlinginc.com/pages/services.html
- QuickZone: http://www.tfhrc.gov/its/quickzon.htm
- SCRITS (SCReening for ITS): http://www.fhwa.dot.gov/steam/scrits.htm
- Sketch Methods: http://plan2op.fhwa.dot.gov/toolbox/toolbox.htm
- SMITE (Spreadsheet Model for Induced Travel Estimation): http://www.fhwa.dot.gov/steam/smite.htm
- SPASM (Sketch Planning Analysis Spreadsheet Model): http://www.fhwa.dot.gov/steam/spasm.htm
- SPF (Simplified Project Forecasting): http://www.fhwa.dot.gov/
- STEAM (Surface Transportation Efficiency Analysis Model): http://www.fhwa.dot.gov/steam/index.htm
- TEAPac/SITE: http://www.strongconcepts.com/Products.htm
- TrafikPlan: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=162
- TransDec (Transportation Decision): http://tti.tamu.edu/researcher/v34n3/transdec.stm

- Trip Generation: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=179
- Turbo Architecture: http://itsarch.iteris.com/itsarch/html/turbo/turbooverview.htm

A.2 Travel Demand Models

The following is a listing of travel demand modeling tools that are available:

- b-Node Model: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=482
- CUBE/MinuTP: http://citilabs.com/v.cube/cube.html
- CUBE/TP+/Viper: http://citilabs.com/v.cube/cube.html
- CUBE/TranPlan: http://citilabs.com/v.cube/cube.html
- CUBE/TrIPS (Transport Improvement Planning System): http://citilabs.com/v.cube/cube.html
- emme/2: http://www.inro.ca/
- IDAS (ITS Deployment Analysis System): http://idas.camsys.com/
- MicroTRIMS: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=483
- QRS-II: http://my.execpc.com/~ajh/index.html
- SATURN (Simulation and Assignment of Traffic to Urban Road Network): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=157
- TModel: http://www.tmodel.com
- TransCAD: http://www.caliper.com/tcovu.htm
- TRANSIMS (Transportation Analysis and Simulation System): http://transims.tsasa.lanl.gov/

A.3 Analytical/ Deterministic Tools (HCM Methodologies)

There is a wide array of analytical/deterministic tools currently available, including:

- 5-Leg Signalized Capacity: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=36

- aaSIDRA (Signalized & unsignalized Intersection Design and Research Aid): http://www.aatraffic.com/SIDRA/aboutsidra.htm
- Arcady (Assessment of Roundabout Capacity and Delay): http://www.trlsoftware.co.uk/productARCADY.htm
- CATS (Computer Aided Transportation Software): http://tti.tamu.edu/product/software/cats/
- CCG/Calc2 (Canadian Capacity Guide): http://www.bagroup.com/Pages/software/CCGCALC.html
- CINCH: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=4
- CirCap (Circle Capacity): http://www.teppllc.com/publications/CIRCAP.html
- DELAYE: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=407
- dQUEUE-TOLLSIM (Dynamic Toll Plaza Queuing Analysis Program): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=290
- FAZWeave: http://tigger.uic.edu/~jfazio/weaving/
- FREWAY: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=291
- FRIOP (The Freeway Interchange Optimization Model): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=408
- General Purpose Queuing Model: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=409
- GradeDec 2000: http://www.gradedec.com/
- HCS (Highway Capacity Software) 2000: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=48
- HiCAP (Highway Capacity Analysis Package): http://www.hicap2000.com/
- Highway Safety Analysis: http://www.x32group.com/HSA_Soft.html
- HCM/Cinema: http://www.kldassociates.com/unites.htm
- ICU (Intersection Capacity Utilization): http://www.trafficware.com/ICU/index.html
- IQPac (Intersection Queue Analysis Package): http://www.itsa.org/committe.nsf/1dfaefa4b7926600852565d8004a23c7/1366c5b2fb4066f4852563a200704f24?OpenDocument

- Left-Turn Signal/Phase Warrant Program: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=56
- NCAP (iNtersection Capacity Analysis Package): http://www.tmodel.com/
- Picady (Priority Intersection Capacity and DelaY): http://www.trlsoftware.co.uk/productPICADY.htm
- RoadRunner: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=85
- SIG/Cinema: http://www.kldassociates.com/unites.htm
- SIPA (Signalized Intersection Planning Analysis): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=22
- SNAG/PROGO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=78
- SPANWIRE: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=304
- SPARKS: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=305
- SYNCHRO: http://www.trafficware.com/
- TEAPac (Traffic Engineering Applications Package)/NOSTOP: http://www.strongconcepts.com/Products.htm
- TEAPac/SIGNAL2000: http://www.strongconcepts.com/Products.htm
- TEAPac/WARRANTS: http://www.strongconcepts.com/Products.htm
- TGAP (TModel's Gap Analysis Program): http://www.tmodel.com/
- TIMACS: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=92
- Traffic Engineer's Toolbox: http://home.pacifier.com/~jbtech/
- Traffic Noise Model: http://www.thewalljournal.com/a1f04/tnm/
- TRAFFIX: http://wtraffixonlineww..com/
- TSDWin (Time Space Diagram for Windows): http://www.fortrantraffic.com/whatsnew/new2.htm
- TS/PP-Draft (Time-Space/Platoon-Progression): http://www.tsppd.com

- WEST (Workspace for Evaluation of Signal Timings): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=126

- WHICH (Wizard of Helpful Intersection Control Hints): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=127

- WinWarrants: http://home.pacifier.com/~jbtech/

A.4 Traffic Optimization

Examples of traffic optimization tools include the following:

- MAXBAND: http://www-cta.ornl.gov/research/its/maxband.htm

- PASSER (Progression Analysis and Signal System Evaluation Routine) II-02: http://ttisoftware.tamu.edu/fraPasserII_02.htm

- PASSER III-98: http://ttisoftware.tamu.edu/fraPasserIII_98.htm

- PASSER IV-96: http://ttisoftware.tamu.edu/fraPasserIV_96.htm

- SNAG/PROGO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=78

- SOAP: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=435

- SYNCHRO: http://www.trafficware.com/

- TEAPac/NOSTOP: http://www.strongconcepts.com/Products.htm

- TEAPac/SIGNAL2000: http://www.strongconcepts.com/Products.htm

- TEAPac/WARRANTS: http://www.strongconcepts.com/Products.htm

- TRANSYT-7F: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=437

- TSDWIN: http://www.fortrantraffic.com/whatsnew/new2.htm

- TS/PP-Draft: http://www.tsppd.com

A.5 Macroscopic Simulation Models

The following are examples of macrosimulation traffic analysis tools, along with their web site contact information:

- BTS (Bottleneck Traffic Simulator): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=287
- CONTRAM (CONtinuous TRaffic Assignment Model): http://www.contram.com/
- FREQ: http://www.its.berkeley.edu/computing/software/FREQ.html
- KRONOS: http://www.its.umn.edu/labs/itslab.html
- METACOR/METANET : http://www.inrets.fr/ur/gretia/METACOR-Ang-H-HajSalem.htm
- NETCELL : http://www.its.berkeley.edu/computing/software/netcell.html
- SATURN: http://www.its.leeds.ac.uk/software/saturn/index.html
- TRAF-CORFLO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=441
- TRANSYT-7F: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=437
- VISTA (Visual Interactive System for Transport Algorithms): http://its.civil.northwestern.edu/vista/

A.6 Mesoscopic Simulation Models

Three examples of mesoscopic simulation tools include:

- DYNAMIT-P, DYNAMIT-X, DYNASMART-P, DYNASMART-X: http://www.dynamictrafficassignment.org
- MesoTS: http://plan2op.fhwa.dot.gov/pdfs/Pdf2/mesoscopic.pdf

A.7 Microscopic Simulation Models

Some examples of microscopic traffic simulation models include:

- AIMSUN2 (Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks): http://www.tss-bcn.com/aimsun.html
- ANNATOLL: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a4
- Autobahn: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a5
- CASIMIR: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a6

- CORSIM/TSIS (Traffic Software Integrated System): http://www.fhwa-tsis.com/
- DRACULA (Dynamic Route Assignment Combining User Learning and microsimulAtion): http://www.its.leeds.ac.uk/software/dracula/
- EVIPAS: http://goulias2.pti.psu.edu/projects/p-evipas.htm
- FLEXSYT II: http://152.99.129.29/cdrom/2065.pdf, http://avvisn0.rws-avv.nl/cgi-bin/wdbcgiw/avv/AVV.home
- FREEVU: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a10
- HiPerTrans (High Performance Transport): http://www.cpc.wmin.ac.uk/~traffic/
- HUTSim (Helsinki University of Technology Simulator): http://www.hut.fi/Units/Transportation/HUTSIM/
- INTEGRATION: http://www.intgrat.com/
- MELROSE (Mitsubishi ELectric ROad traffic Simulation Environment): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a14
- MicroSim: http://www.zpr.uni-koeln.de/GroupBachem/VERKEHR.PG/
- MICSTRAN (MICroscopic Simulator model for TRAffic Networks): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a16
- MITSIM: http://web.mit.edu/its/products.html
- MIXIC: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a18
- NEMIS: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a19
- PADSIM (Probabilistic ADaptive SImulation Model): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a21
- PARAMICS: http://www.paramics-online.com/
- PHAROS (Public Highway And ROad Simulator): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a23
- PLANSIM-T: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a24
- ROADSIM (Rural Road Simulator): http://www.kldassociates.com/simmod.htm
- SHIVA (Simulated Highways for Intelligent Vehicle Algorithms): http://almond.srv.cs.cmu.edu/afs/cs/usr/rahuls/www/shiva.html

- SIGSIM: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a26
- SIMDAC: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a27
- SIMNET: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a28
- SimTraffic: http://www.trafficware.com/simtraffic.htm
- SISTM: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a29
- SITRA B+: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a30
- SITRAS: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a31
- SmartPATH: http://www-path.eecs.berkeley.edu/~delnaz/SmartPath/sm.html
- TEXAS (Traffic Experimental Analytical Simulation): http://www-mctrans.ce.ufl.edu/ti_ved/store/shopcart1.asp
- TRAFFICQ: http://www.mva-group.com
- TRANSIMS: http://transims.tsasa.lanl.gov/
- TRARR: http://www.engr.umd.edu/~lovell/lovmay94.html
- TWOPAS: http://www.tfhrc.gov/safety/ihsdm/tamweb.htm
- VISSIM: http://www.itc-world.com/
- WATSim (Wide Area Traffic Simulation): http://www.kldassociates.com/unites.htm

A.8 Integrated Traffic Analysis Tools

There are some programs or utilities available that integrate two or more programs to provide a common data input format all allow a user to run several programs. Some examples of integrated traffic simulation models include:

- AAPEX (Arterial Analysis Package Executive): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=426
- ITRAF: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=445
- PROGO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=78